Soilborne Diseases in Tomato High Tunnels: An Emerging Threat

Anna L. Testen and Sally A. Miller

INTRODUCTION

Soilborne diseases greatly limit yield, but are often ignored because they are difficult to detect and identify. Many tomato growers use high tunnels to extend the growing season and reduce environmental variability, but the protected conditions and lack of rotation in high tunnels create conducive conditions for the development of soilborne disease complexes (Last et al. 1969).

Pathogens in these complexes can greatly reduce tomato yields (Campbell and Hall, 1982), are difficult to manage (Colla et al. 2012), and have broad host ranges (Inderbitzin et al. 2013). A soilborne disease complex consisting of corky root rot (*Pyrenochaeta lycopersici,* Fig. 1A), black dot root rot (*Colletotrichum coccodes,* Fig. 1B), Verticillium wilt (*Verticillium dahliae,* Fig 1C), and root knot nematode (*Meloidogyne incognita* and *M. hapla,* Fig 1D) was first identified in several Ohio high tunnels in 2015 (Vrisman et al. 2017).

Despite the potential of these diseases to greatly reduce tomato yields, no information was available on the distribution of these diseases in Ohio high tunnels. A survey was designed and conducted to identify the distribution of these diseases within Ohio high tunnels, in order to provide farmers with improved recommendations for soilborne diseases.

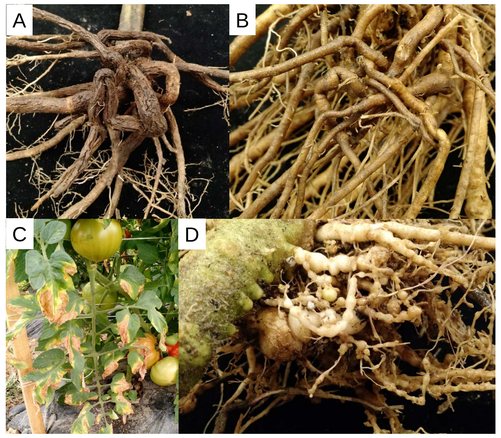


Figure 1 Characteristic symptoms of corky root rot (A), black dot root rot (B), Verticillium wilt (C) and root knot nematode (D).

OBJECTIVES

The objectives of this study were to i) determine the incidence of corky root rot, black dot root rot, Verticillium wilt, and root knot nematodes in Ohio high tunnels and ii) inform growers of the diseases present in their high tunnels and provide customized recommendations for disease management.

MATERIALS AND METHODS

Sample collection Farmers collected soil samples and returned them to one of six produce auctions (Fig. 2) or sent samples directly to OARDC.

- Samples (n=68 high tunnels on 34 farms) were received from 17 Ohio counties (Fig. 2).

Sample processing Sample were homogenized and large aggregates were broken by hand. Samples were stored at 4°C until used.

PCR-based assays A subsample of each soil was taken and air-dried, and DNA was extracted with the PowerSoil DNA extraction kit (MoBio Laboratories, Carlsbad, CA).
The following species-specific primers were used to assay for each pathogen:

- *P. lycopersici* (nested PCR): ITS4/ITS5, then Plyc1F/Plyc1R or Plyc2F/Plyc2R (Infantino and Pucci 2005)
- *C. coccodes* (nested PCR): CC1F1/CC2R1, then CC1NF1/CC2NR1 (Cullen et al. 2002)
- *V. dahliae*: Df/Dr (Inderbitzin, et al. 2013)

Greenhouse bioassay 'Moneymaker' tomato seeds were planted into each soil (two pots per soil), and tomatoes were grown for nine weeks. Plants were harvested and roots were washed and evaluated for root rot severity, taproot rot severity (rated on ordinal scale with "1" meaning no tap root rot and "5" meaning complete taproot rot), and root knot nematode galling.

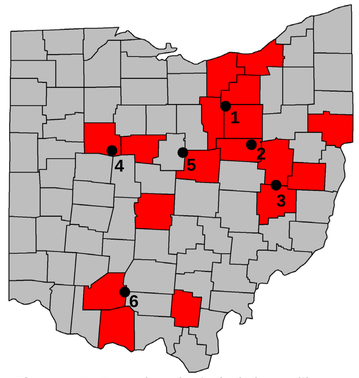


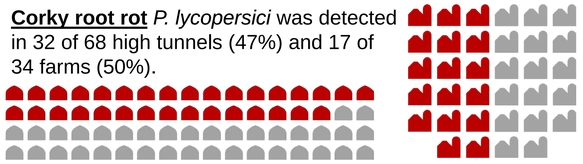
Figure 2 Counties included in soilborne disease survey (red) and locations of produce auctions. Produce auctions are 1) County Line, 2) Mt. Hope, 3) Peoli, 4) Scioto Valley, 5) Owl Creek, and 6) Bainbridge.

RESULTS

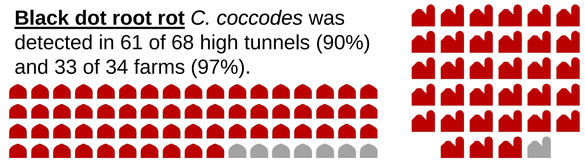
Disease incidence

The graphics below show the number of high tunnels (n = 68) and farms (n = 34) in which each pathogen was detected. Scarlet indicates disease presence, while gray indicates disease absence.

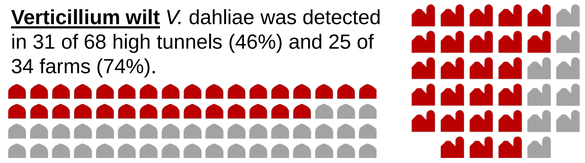
Corky root rot *P. lycopersici* was detected in 32 of 68 high tunnels (47%) and 17 of 34 farms (50%).



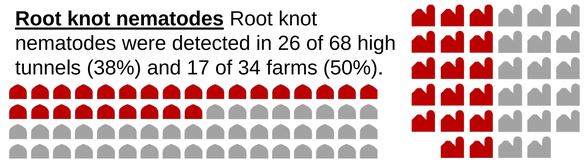
Black dot root rot *C. coccodes* was detected in 61 of 68 high tunnels (90%) and 33 of 34 farms (97%).



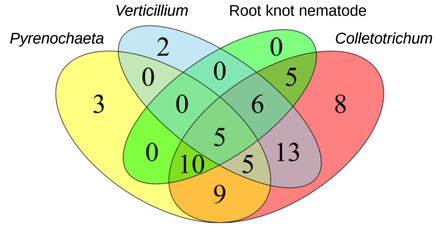
Verticillium wilt *V.* dahliae was detected in 31 of 68 high tunnels (46%) and 25 of 34 farms (74%).



Root knot nematodes Root knot nematodes were detected in 26 of 68 high tunnels (38%) and 17 of 34 farms (50%).

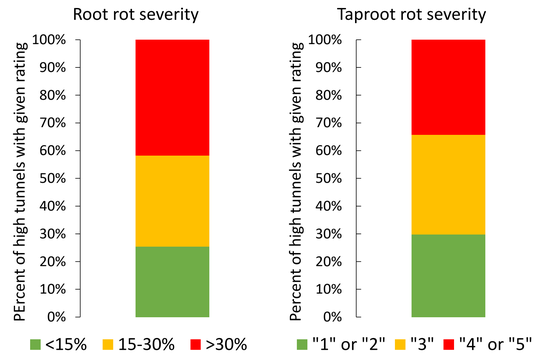


Occurrence of co-infestations



The Venn diagram above shows the occurrence of co-infestations in high tunnels soils. The numbers shown are the number of high tunnels with each pathogen combination. All four pathogens were detected in five tunnels, and the most common triple infestation was *Pyrenochaeta* – *Colletotrichum* – root knot nematode.

Root rot and taproot rot severity



The graphs show the percentage of high tunnel soils that produced tomatoes with a given root rot or taproot rot severity rating. Root rot severity greater than 30% is cause for concern and was observed in 41% of high tunnel soils. Taproot rot severity ratings of "4" and "5" are also of cause for concern and were observed in 34% of high tunnels.

SIGNIFICANCE AND CONCLUSIONS

This is the first comprehensive survey of soilborne diseases tomato high tunnels in Ohio.

- Diseases were more widespread than anticipated.
- Participating farmers were informed of their results and provided with customized management recommendations.
- Farmers and researchers have a better understanding of the soilborne diseases present in Ohio high tunnels.
- Farmers have improved awareness of soilborne disease management options.
- Several of the diseases in these complexes (Verticillium wilt and root knot nematode) affect other vegetable crops, and farmers have improved awareness of these risks.
- These findings will help to promote the use of established soilborne disease management practices including anaerobic soil disinfestation and grafting onto disease resistant rootstocks (Fig. 3).

Figure 3 Research on anaerobic soil disinfestation (left) and grafting (right) conducted in the Miller Lab to improve soilborne disease management for Ohio tomato growers.

BIBLIOGRAPHY

Campbell, R.N., Schweers, V.H., Hall, D.H. 1982. Corky root of tomato in California caused by *Pyrenochaeta lycopersici* and control by soil fumigation. Plant Disease 66:657-661.

Colla, P., Gilardi, G., Gullino, M.L. 2012. A review and critical analysis of the European situation of soilborne disease management in the vegetable sector. Phytoparasitica 40:515-523.

Cullen, D.W., Lees, A.K., Toth, I.K., Duncan, J.M. 2002. Detection of *Colletotrichum coccodes* from soil and potato tubers by conventional and quantitative real-time PCR. Plant Pathology 51:281-292.

Infantino, A., and Pucci, N. 2005. A PCR-based assay for the detection and identification of *Pyrenochaeta lycopersici*. European Journal of Plant Pathology 112:337-347.

Inderbitzin, P., Davis, R.M., Bostock, R.M., Subbarao, K.V. 2013. Identification and differentiation of *Verticillium* Species and *V. longisporum* lineages by simplex and multiplex PCR assays. PLoS ONE 8:e65990.

Last, F.T., Ebben, M.H., Hoare, R.C., Turner, E.A., Carter, A.R. 1969. Build-up of tomato brown root rot caused by *Pyrenochaeta lycopersici* Schneider and Gerlach. Annals of Applied Biology 64:449-459.

Vrisman, C.M., Testen, A.L., Elahi, F., Miller, S.A. 2017. First report of tomato brown root rot complex caused by *Colletotrichum coccodes* and *Pyrenochaeta lycopersici* in Ohio. Plant Disease 101: 247.

ACKNOWLEDGEMENTS

This research was funded by the Ohio Department of Agriculture through a Specialty Crops Block Grant. We thank Thom Harker, Brad Bergefurd, Rory Lewandowski, Chris Smedley, and produce auction managers for help coordinating sample collection.